May 1999
THE INFRASTRUCTURE AND FINANCIAL MARKETS DIVISION Vol. 5 No. 1
IFM BULLETIN
Sustainable Development Department of the Inter-American Development Bank

Quantifying the Value of Flexibility

The most-used methodology for evaluating projects and other initiatives tends to undervalue a project. This method, which is based on the Net Present Value (NPV), does not capture volatility, the value of the flexibility inherent over a project's life, and the subsequent decisions that managers can make. Option-pricing models, which incorporate uncertainty, have been generally restricted to financial assets, but companies are making limited use of them with respect to project finance and investment in real assets. In the context of project analysis, a real-option approach allows a company to evaluate decisions that might be made in the future, when additional information is available. This includes the option to abandon, defer, expand, switch and/or modify a project.

Uncertainty creates options, which a company can exercise to increase the value of the project and hence that of the company. However, an established methodology and framework does not always recognize and quantify the options available. Companies often undertake projects that appear to have a negative NPV, because they implicitly consider the options that participation in an initial project will give them. Or, they may invest in a potentially profitable project if they have the option to abandon the project should the situation not work out as planned.

The real-options approach enhances the capability of fair valuation and introduces a new method for investment valuation, capital budgeting and decision-making.

This article elaborates on the use of the real option framework as a complement to NPV in the evaluation of projects, addressing limitations of the approach. It emphasizes the importance of evaluating options from the point of view of lenders and particularly Multilateral Development Banks (MDBs), which are increasingly financing private-sector projects.

Definition of Options

Options give entities (people and companies) the right, but not the obligation, to buy or sell an asset at a predetermined price for a determined period. "Call" options give them the right to buy, "put" options the right to sell. Following the development of the basic option-pricing model by Black and Scholes, financial options on the stock and bond markets, as well as on the derivative markets, have grown exponentially. The option concept and methodology can also be used to value the implicit or imbedded options associated with a number of real transactions: convertible debt, warrants prepayment options, etc.

Options associated with investments that are not financial instruments provide a company with the possibility of changing a course of action. For example, a company that acquires a factory has the option to expand production; if it acquires a piece of land, it has the right to drill for oil. Therefore, the value of the company has to be somewhat adjusted to reflect the subsequent actions available to the company.

Project-Evaluation Methods: Traditional NPV Approach

Traditional valuation methods use projected cash flow based on estimates of the initial investment and forecasts of sales, costs, profits, etc., as well as on estimates of the terminal value. This is based on a sort of "fixed path" of future development. More sophisticated approaches include sensitivity analysis of selected variables or Montecarlo simulations. These approaches, while valuable, remain focused on a "fixed path" concept and do not incorporate the options that companies have during the course of the project and that are made possible by the initial investment.

The Real-Options Approach

The real-option approach requires a new way of thinking on the part of managers, executives and decision-makers, by uncovering and identifying options that exist in investment decisions. Some examples of types of real options are explained below:

- ***Abandonment or Exit Options.*** At the end of a given period, when more information is available, the company can decide to abandon a project and realize the liquidation value of the existing project. A company would exercise this option if the value of the asset (project) were lower than its liquidation value. The liquidation value provides a floor on the value of the project; a project with an exit option is worth more than one without.

(continued on page 4)

Contents

Whither Risk Management?

The management of financial or market risk has been central to the most recent modifications to the Core Principle of Bank Supervision promulgated by the International Committee on Bank Supervision, under the auspices of the Bank of International Settlements (BIS). The BIS approach goes far beyond its initial emphasis on credit risk—the requirement that banks hold a minimum level of capital equal to 8% of risk adjusted assets. The management of market risk requires banks to measure their overall exposure to changes in market and to hold sufficient capital to protect depositors and other creditors against adverse movement in these markets. If properly measured, the sensitivity to these market factors includes not only the change in economic value associated with assets and liabilities, but also the maintenance of capital to support off balance sheet activities risks. Financial risk management should likewise incorporate "credit sensitivity," the exposure of underlying lending and investment portfolios. The recently developed markets for credit derivatives are one attempt to price and hedge "credit sensitivity." Finally, risk capital is needed to support the legal and operational risk associated with new activities.

The modern risk-management approach measures the risk associated with each factor in terms of standard deviation, and then uses portfolio theory to combine the risks while accounting for the risk reduction afforded by the less-than-perfect correlation among risk factors. Rather than holding capital against each risk, the required capital is calculated against the one-sided probability that the value of the entire portfolio of risks will fall within a specific period. The probability is often set at a .5% significance level. The associated time period is usually related to the time needed to liquidate the portfolio under stress. Thus the credit risk of a lending portfolio might be evaluated with a 1-year holding period while interest rate risk associated with government bonds in the trading portfolio might be evaluated with a 2- or 3-day period.

Within the Latin American and Caribbean region, financial risk management is only being implemented to a limited degree and in a small number of institutions. The effort to measure and control market risks is being lead largely by the international banks active in the region. The few purely domestic banks that are undertaking a comprehensive risk management program often indicate that they began undertaking financial risk management programs because international risk rating agencies began to ask them what they were doing in terms of risk management. Some of the banks that have issued ADRs in the U.S. market indicate that investment analysts are beginning to ask these same questions. More recently, several of the bank superintendencies of the region, following the lead of the BIS, have begun to analyze how they can best evaluate the degree to which their banks are monitoring and controlling financial risk. While no regulator in the region has begun to require banks to hold capital against market risk, this next step is not far off.

Implementing a comprehensive risk management system is expensive—it is important that financial regulators, commercial banks and the multilateral community which are supporting expanded use of risk management, understand the costs and the benefits of being able to monitor and control their exposures to market risk. This paper addresses some of the underlying issues. We will first review the theoretical position that holds that risk management has no value and will then discuss a number of value-creating factors associated with risk management.

Three separate theoretical models of financial decision-making behavior question the rationality of hedging behavior. *Utility Theory* provides clear evidence that a risk-adverse consumer is willing to pay a premium for risk reduction, or alternatively that a risk hedge or insurance policy will always be purchased by a risk adverse consumer as long as the hedge is priced at its actuarially fair value. Nevertheless, a risk neutral investor would be indifferent between the hedged and unhedged transaction, but would reject the hedge if a risk premium had to be paid. Since most corporations are assumed to operate as if they were risk neutral, some have questioned the value of costly hedging transactions. *Portfolio Theory* holds that from the point of view of a diversified investor, only systemic risk is rewarded. The gains or losses associated with idiosyncratic risk will not be rewarded as they can be diversified away. Thus, some observers have argued that hedging, to the extent that it is costly, is value reducing from the perspective of

The Inter-American Development Bank

IFM **BULLETIN**

Editorial Board
A. Aguila, E. Machado, T. Powers, P. Masci

Editor for this issue
Kim Staking

1300 New York Ave., N.W.
Washington, D.C. 20057
Stop W-0508
Phone: 202-623-1608
Fax: 202-623-2157
Internet: IFMMAIL@IADB.ORG

The Infrastructure and Financial Markets Division of the IDB provides technical and advisory support, research and dissemination within the IDB group. The Bulletin is an internal document for Staff that aims to provide a source of information on relevant topics in infrastructure, finance and related areas.

the shareholder. *Option Pricing Theory* holds that the value of an option increases with volatility. Since the equity value of a levered firm can be shown to be equal to an option on the value of the firm assets with a strike price equal to the face value of the debt, shareholder value would be reduced through hedging behavior that reduced volatility.

As we observe a significant level of hedging activities by levered firms that otherwise make decisions as if they were risk neutral and whose shareholders are well-diversified institutional investors, we must look for other explanations for hedging behavior. Recent developments in Financial Theory have given us a far richer view of the dynamics of financial markets than that accorded by the simplistic, static views of investor behavior expressed in the prior paragraph that negate the value of hedging. It is the violation of the basic assumption of the underlying models that must be used to explain hedging behavior.

The following is a partial list of the many reasons that firms, including financial institutions, choose to hedge even when hedging is costly.

Taxes. To the extent that marginal taxes are an increasing function of income and tax loss carry backs and carry forwards are limited, there is a financial advantage to reducing the volatility of reported income. Hedging is only one of many ways to smooth income, but it is a powerful way to avoid very large shifts in value and reduce associated tax liabilities.

Risk aversion by owners and management. While some shareholders may be well diversified and therefore indifferent to idiosyncratic risk, the same may not true for all shareholders. Smaller firms, may be more risk adverse. Likewise, managers and employees may not be as well diversified. Although stock options have been used as a tool for aligning the interests of shareholders and managers, as far as the core business interests go, options are less effective for eliminating the exposure to other risks that are outside of management's control.

Risk aversion by other agents. In addition to management and employees, many other agents become involved with a business enterprise and many of these agents are either risk averse or are forced to act as if they were risk averse because of their contractual arrangements. Creditors are a good example. Lending contracts seldom allow creditors to capture any upside potential, and spreads are too low to contemplate a high probability of large losses. Thus, lending agreements and bond covenants often insist on insurance of key assets and maintenance of appropriate hedges against market risk. Other agents, such as suppliers, subcontractors, and even clients, are interested in knowing that the firm will be around as the cost of setting up a relationship is high.

Information asymmetries and signaling. Hedging may be used to protect intangible assets associated with growth opportunities such as ongoing research and development. As these are hard to measure and may be difficult to communicate, a firm may hedge in order to protect the future value of these intangibles. Some research correlates hedging behavior with these intangibles, suggesting that costly hedging may provide a signal as to the value of these growth opportunities.

Bankruptcy costs and financial distress. The transaction costs, e.g., legal costs, etc., associated with bankruptcy are very high. Likewise, the costs associated with financial distress as one approaches insolvency, e.g., high interest rates, loss of access to credit, etc, result in the penalty applied by financial markets to negative outcomes being greater than the offsetting gains in an otherwise symmetric distribution of risk. Hedging is one way to reduce this asymmetry and increase value.

Concentration on core activities. It is important for a firm to concentrate on its core competencies. The managers of a manufacturing or retail firm are likely selected because of their ability to manage production and distribution costs or to identify future consumer demand. These individuals may not have the background or training in managing financial risks. Any time they spend worrying about these risks detracts them from their core competency. Hedging strategies allow them to maintain their concentration.

New or expanded business opportunities. Hedging can help provide new business opportunities. This is especially the case for financial institutions, but many firms are able to either provide hedging opportunities to others or discover that they are able to offer a new product because of hedging activities. A bank, for example, can only provide a certain amount of risk transfer services to its clients using its own capital.

However, by creating offsetting positions among a wide group of its clients, it is able to convert price risk to credit and operational risk. Financial institutions often discover that the provision of hedging services can develop into an important line of activity.

In summary, for a multitude of reasons, firms should choose to manage risk, even when risk management is costly. A comprehensive program of risk management such as the one jointly developed by the Inter-American Development Bank and Grupo Santander can help companies take advantage of these benefits./

Kim B. Staking
Senior Financial Economist
Sustainable Development Department
Infrastructure and Financial
Markets Division

Quantifying the Value of Flexibility

(from page 1)

- ***Operating Options.*** In many cases, projects can be designed so that output can be reduced in the future. The contraction option gives the company the right to reduce the scale of the project in the event of unfavorable conditions.
- ***Staging Options.*** A company can decide to build capacity in excess of the expected output so that greater than anticipated demand can be easily accommodated. The expansion option provides management with flexibility and the possibility of expanding production if conditions warrant it, and increasing the profitability of the initial investment.
- ***Timing Options.*** Used exclusively in the United States, this could be the case of the owner of a lease on an undeveloped oil reserve who has the right of developing that reserve.
- ***Growth Options.*** An initial investment may lead to other more profitable opportunities later, including the option of switching project operations. A typical case would be shutting down or restarting operations when conditions justify doing so.

A common feature of real options s that they open opportunities and ıllow a company to capture the value ɔf flexibility. In each case, a project ʍith that feature would be more valuıble than one without it. In practical :erms, real options rely on the availıbility of information that allows :ompanies to make more educated decisions. The inputs needed for the valuation of the options are those required to assess financial options: value of the underlying asset, variance in its value, exercise price, time to expiration and risk-free rate. The estimation of model inputs can be difficult, particularly in an emerging market environment, but the options need to be evaluated to capture the full option.

Valuation of Real Options

Estimates of the inputs to value "real options" depend on the specific circumstances of each project. The value of the underlying assets is the project itself, and its current value is the NPV estimated on the basis of the traditional analysis. The variance of the value of the asset can be similated by the variance of the cash flows from the project. The exercise price of the real option is the cost of making the investment (e.g., expansion). The time to expiration should be estimated on the basis that the option expires when the decision to expand or delay is no longer available. The risk-free zero coupon yield of a government bond with a maturity equal to the life of the option should be used. In performing the calculations, we assumed the conditions underlying the Black-Scholes model apply; e.g, we know the current value of the project and the variance remains constant over the life of the option. Two basic examples, one, delaying or postponing a project and two, expanding it-have been drawn from Wayne Winston.

In practical terms, real options rely on the availability of information that allows companies to make more educated decisions.

In the first example, a company has the option of building a plant now at a cost of US$100 million. This company obtains revenues for US$104 million next year. With an interest rate of 8%, the NPV of the investment is -US$3.7 million and the project does not appear feasible. Assuming that the project can be postponed one or two years and the market and technology are particularly volatile with an annualized standard deviation of 60%, we want to evaluate the right, i.e., the option, of postponement. To value that option, we would look at a revised Black-Scholes model.

The option of delaying the project is very valuable and in fact is worth US$25.2 million, which more than offsets the negative NPV value of the same project without the option. Therefore, the company should not discard the project, but should wait and undertake the project when more information is available. The option to delay underscores interesting implications. Based on traditional NPV analysis, the project has a negative value, but it is still valuable due to the value of the option to delay. In other words, a negative traditional NPV does not imply that the rights related to the project are worthless. In addition, the valuation of the option to delay suggests that the project should not be dismissed, but that the company may gain by waiting and accepting the project in the future. This situation occurs when the company has the rights related to a project for a long time and the volatility of project cash flows is high.

Volatility has negative connotations. However-and this is at first glance counterintuitive-high volatility is actually one of the factors that makes options valuable. For more stable businesses, e.g., utilities, the option to postpone/expand would be less valuable.

The value of the option to delay will be reduced over time (option time decay) while the option value will increase (or decrease) as the value of the project increases (decreases) due to changes in the underlying market. The investor must monitor the project and make the deci-

Quantifying the Value of Flexibility

(from page 4)

sion at the appropriate time.

In our second example, a company has the option of investing in an initial project, giving the company the opportunity of owning a bigger technology that will be available 4 years later at a cost $1.5 billion. The NPV of the initial project is a negative $56 million. However, the estimated NPV of the expanded project is $597 million. If the company does not invest in the initial project, it will not have the option of a bigger project.

What decision should the company make? The value of the option to expand can be calculated using the Black-Scholes formula (time = 4 years, interest rate = 10%, the value of the underlying assets = $597 million and the strike price and volatility = 35%). Using the Black-Scholes model we can calculate the option to expand to US$69 million, which more than offsets the negative NPV of the initial project and makes the project attractive. Similar results are obtained running a simulation of the discounted cash flow of the project including the option to expand.

These two examples demonstrate the insight that the use of the real options methodology can provide.

When we apply the methodology to projects we may encounter a number of problems; e.g., if the project is not a traded asset and it is difficult to estimate its value and variance; the time of the exercise of the option is not always specified; the behavior of prices may not follow the pattern required by the option-pricing model.

Limitations of the Real-Options Approach

The real options approach remains an inexact science. And we must recognize a number of limitations.

Once the problem is introduced into the real-options methodology, we need to look to the source of information to provide the inputs to evaluate the option. The main source of information to evaluate the options is the market. Typically, the information needed includes the level of interest rates, prices and volatility, exercise price, and time to expiration. Obviously, the more efficient the markets and the closer the real options are to the financial options, the more reliable the results will be. In this context, we must deal with a number of shortcomings, particularly in the case of project finance in emerging markets. The first shortcoming is that of "model risk" inherent in all financial valuation. That is, once a real option is identified and translated into a mathematical model, the lack of perfect information does not allow the model to give exact results. The accuracy of the results decreases as the distance from the market information increases.

The real-options aproach leads to more educated decisions than do traditional methods. In any event, the advances of the real options approach move rapidly and the models become more sophisticated and information more accurate and reliable.

Other shortcomings are related to the unavailability of observable prices, leading to the difficulty of estimating volatility (which is crucial to evaluating options), or to the difficulty of indicating appropriate proxies. Volatility may be difficult to estimate for a project. One possibility might be to look at volatility of cash flows (as indicated above) or that for companies in a similar industry. However, determining these values remains a challenge. Another possibility is to value the option for a range of volatility values.

Liquidity is another problematic issue, in the sense that if a company decides to exercise the option to abandon an asset, the market for that particular asset is so thin that the decision to sell an asset moves the prices significantly and not in accordance with the model. These shortcomings are especially relevant for projects in emerging markets where information is either not available or cannot be accurately estimated and used as proxies.

Despite these limitations, the real-options approach leads to more educated decisions than do traditional methods. In any event, the advances of the real options approach move rapidly and the models become more sophisticated and information more accurate and reliable.

Relevance for the Multilateral Development Banks

The issue of the availability of real options, mainly to project sponsors or other parties involved in the project, is of relevance for Multilateral Development Banks (MDBs) and publicly funded institutions. MDB financing of private sector projects, which would not be otherwise financed by the market, opens to project companies, shareholders and sponsors some of the opportunities described above. The identification of the real options that MDB financing makes available is crucial and should be evaluated in the context in which the project takes place. The upside potential should be assessed and an appropriate pricing for MDB participation identified, including a partial appropriation of the additional return available to project companies, shareholders, spon-

Quantifying the Value of Flexibility

(from page 5)

sors or other beneficiaries.

There are various examples of projects financed by MDBs, particularly in the energy sector, wherein additional possibilities become available, once the initial investment is made. For instance, gas pipelines can be extended to other areas, other segments of the population and/or other countries. Given the process of integration that is taking place in many regions (e.g., Mercosur), due to the initial investment, the project company has the opportunity of expanding the project and discovering a substantial upside potential that will increase its return on investment. The same applies to transportation projects in which additional segments of a toll road are assigned to the company that won a previous bid. These situations open up a number of questions related to the support that MDBs give to private participation, particularly in infrastructure projects, and underline the importance of a sound legal and regulatory framework within which the project takes place.

We have seen how valuable the option of abandoning a project could be for the project company. On the other hand, MDBs want to finance private sector projects that have a long-term impact on the economy of the recipient country. Therefore, abandonment options incorporated in contracts or other forms of abandonment of a project financed by MDBs should be scrutinized to ensure that inappropriate support and subsidy to the private sector is not granted.

The presence of MDBs in the financing of a given project allows the project company to obtain options that would not be otherwise available. This is reflected in an increased return on investment and a boost in the share holders value. MDBs need to incorporate an understanding of these option values (and the distortions that can arise) when selecting their projects and making pricing decisions.

The presence of MDBs in the financing of a given project allows the project company to obtain options that would not be otherwise available. This is reflected in an increased return on investment and a boost in the shareholder's value. MDBs need to incorporate an understanding of these option values (and the distortions that can arise) when selecting their projects and making pricing decisions.

This approach would provide the framework and develop a methodology to detect and evaluate real options in private projects financed. It would avoid undue support to the private sector and would spell out ways in which the additional income could be shared.

Conclusions

The real-options approach is the extension of option-pricing theory to real, non-financial, assets; it is an innovative method, which introduces financial market discipline to the evaluation of non-financial assets by allowing the calculation of the impact of uncertainty and hence valuing flexibility. The methodology provides the basis for the somewhat counterintuitive argument that uncertainty is not a problem to be avoided or removed. In reality, if a company is well positioned, uncertainty can be a source of value.

One of the important and probably long-standing contributions of the real-options approach goes beyond the computational aspects of sophisticated formulas. This approach forces managers and executives to think differently about investment decisions, focusing more on the long-term and strategic impact than on the return of an individual project or investment.

Pietro Masci, Chief
Infrastructure and Financial
Markets Division

Bibliography on "Real Options"

The bibliography on the issue of "Real Options" is large and it covers related topics in financial/economics, sector papers including energy options, financial options, corporate/industrial economics (CAPM, game theory, etc.), textbooks on finance/economics, mathematics, software and internet sites. The essential bibliography below provides some basic material on the topic.

Amram, M. and N. Kulatilaka. *Disciplined Decisions: Aligning Strategy with Financial Markets*, Harvard Business Review, January-February 1999. This provides the strategic view of investments trying to bridge the gap between innovation and traditional methods and the role of financial markets.

Copeland,T., T. Koller and J. Murrin. *Valuation, Measuring and Managing Value of Companies*, Wiley, NY, 1994. A fundamental text for valuation based on cash flow.

Damodaran, A. *Applied Corporate Finance*, John Wiley and Sons, Inc. New York, 1999. The book covers theory and application in corporate finance, including the use of real options.

Dixit, A. K. and R. S. Pindyck. *investment Under Uncertainty*, Princeton University Press, Princeton, 1994. The book provides the first theoretical approach to capital investment emphasizing the investment behavior of the firm and the subsequent decisions that become available to the firm.

Luenberger, D. *Investment Science*, Oxford University Press, Oxford-New York, 1998. The book covers the main topics on investment with emphasis on quantitative aspects.

Tregeorgis, Lenos. *Real Options in Capital Investment*, Praeger, 1995. The book integrates various contributions to the growing "real options" literature. The book explores the evolution and application of the new method and covers general models of real options as well as specific applications, e.g., optimal land.

Tregeorgis, Lenos. *Real Options*, MIT Press, Cambridge, 1996. The book ex tends the previous book of the author focusing and expanding the material of the previous work.

Winston, W. *Financial Models Using Simulation and Optimization*, Palisade, Newfield, 1998. The book covers the use of simulation and optimization in various areas of finance, e.g. term structure of interest rates. It deals extensively with real options (chapter 55 through 58).

Software: *@Risk and Risk Optimizer* from Palisade introduce the use of simulation and optimization to value options. Various Excel models, using the Solver option, or packages such as "*Evolver*" make the calculations of the value of option. More complex and tailor-made models exist for larger projects.

There are several web sites on real options:
www.Mckinseyquaterly.com/corpfina/
www. Duke.edu/~charvey/
www.real-option.com/book/
www.puc.rio.br/marco.ind/

Invitation to Readers

We welcome contributions from our readers. Articles should be no more than 4 double-spaced pages, preferably in english, and in WordPerfect or Word files. Topics on infrastructure finance, management and regulation, financial markets, and the private sector are to be highlighted in the Bulletin.

Please submit articles, comments, announcements, or other contributions to e-mail: IFMMAIL or to IFM BULLETIN, Stop W-0508.